

# A Fabrication Method for 64-m Antenna Radial Bearing Wear Strip Segments

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*In the construction of the 64-m antennas for the DSN the fabrication of the radial bearing wear strips has been a difficult problem, and one that was not solved satisfactorily during the initial construction. A test project carried out in the JPL machine shop has shown the feasibility of a direct machining process, using a tracer or tape controlled planer. This process can be used for the manufacture of replacement wear strips for those presently installed on the antenna, and can be used with higher hardness steels giving an improved wear life of these components.*

## I. Introduction

On the DSN 64-m antennas, fabrication of the radial bearing runner wear strip segments to the desired flatness tolerance has been very difficult and not completely successful. The wear strips are hardened steel plates 2.86 m (112.5 in.) long formed to an arc 36 deg long on a 4.57-m (15-ft) radius. The manufacturing process that has been used consists of grinding the wear strips flat and then cold-forming them to the desired radius. The cold-forming process has caused a transverse warpage which prevents proper seating of the wear strip on the runner, and requires machining of the outer surface of the wear strip at final assembly. This paper describes a project carried on in the JPL machine shop to test a method of machining

these segments to the desired arc on a planer, holding the desired flatness, and without resorting to the use of a very large boring mill. The fabrication technique is applicable to replacement parts or new construction.

## II. Fabrication Problem

The 64-m antenna radial bearings are made up of three 2-wheel trucks running against the 10 hardened wear strip segments on the face of the 9.14-m (30-ft) diameter runner. The original wear strips were made of T1 steel with a hardness of approximately 24 Rockwell C and a yield strength of  $6.9 \times 10^8 \text{ N/m}^2$  (100,000 psi). The manufacturing process used consisted of grinding the plates in the flat to a thickness tolerance of  $\pm 0.05 \text{ mm}$

(0.002 in.) to assure that the machined concentricity of the runner would be maintained in the hardened wear strip face and that there would be a minimum step across adjacent segment ends. The segments were then cold-formed to the desired radius (the outside radius of the runner) and attached to the runner with counterbored cap screws. It was found that the cold-forming produced an anticlastic distortion of the wear strips in the form of an outward curvature that prevented proper seating of the wear strips on the runner (Fig. 1). The resulting gaps were filled with shim material to distribute the wheel loads from the wear strip into the runner, and the outer surfaces were machined on a very large boring mill to assure a flat outer surface. The shimming process is not satisfactory because it leaves hard spots that cause high local contact stresses on the wheel and the wear strip, which will lead to premature failure of these components.

### III. Test Program

The objective of the test was to determine if the wear strip segments could be machined in the final arc form on a planer, using a tracer attachment, and maintaining the desired thickness tolerance. The test was made using heat-treated 4130 steel rather than T1 because the higher hardness obtainable would be needed in the future construction of larger antennas of similar configuration. The fabrication process used was as follows:

A plate of annealed 4130 steel (oversized to allow for finish machining) was rolled to the approximate curve and then heat-treated to 32-38 Rockwell C. The curved plate edge was machined and then placed on a planer table, edge lengthwise, using angle plates for support, and standard hold-down bolts for clamping (Fig. 2).

A full length template was computer programmed and machined on a numerical control mill to an accuracy of  $\pm 0.05$  mm (0.002 in.).

A hydraulic tracer attachment was set up on the planer, and a special outrigger unit was fabricated to follow the contour, thus positioning a tool to machine the test bearing plate to the required contour on the planer.

The planer action was chosen so that the tool marks would be in alignment with the antenna guide rollers, and would not set up a Brinell action that a milling slab cutter might do. The outer surface was machined in two halves. This was required because the hydraulic tracer attachment used could not move the tool away from the work fast

enough on the return stroke to clear the convex side of the wear strip. Upon machining the inside surface, the tool swept the entire length, since the return stroke was across the concave side of the wear strip and there was no clearance problem.

The tool geometry was ground to a compromise between the "mean" allowable positive rake and the allowable negative rake.

The feed rate was 3.4 mm/s (80 in./min) controlled primarily by the reaction time of the tracer cylinder.

The problems encountered in the prototype test were primarily in the outrigger attachment, which chattered badly if actuated too rapidly, and in the hydraulic tracer unit, which was too slow to maintain the normally required feed rate.

The inspection technique used was twofold. First, while the part was being machined, the thickness was checked to determine if the two sides were parallel and/or how much out of parallel. The test final piece was 0.38 mm (0.015 in.) out of parallel. It is felt that a numerically controlled (NC) machine, cutting full length instead of two halves as the test was run, would easily hold 0.127 to 0.25 mm (0.005 to 0.010 in.) parallel.

Second, the part was then released, and placed in a free state with an indicator taking the place of the tool bit. The part was moved through its longitudinal cycle to determine how closely it matched the template contour. The test piece checked to within 0.508 mm (0.20 in.) of the template. An NC machine, cutting full length, should be within 0.254 mm (0.010 in.).

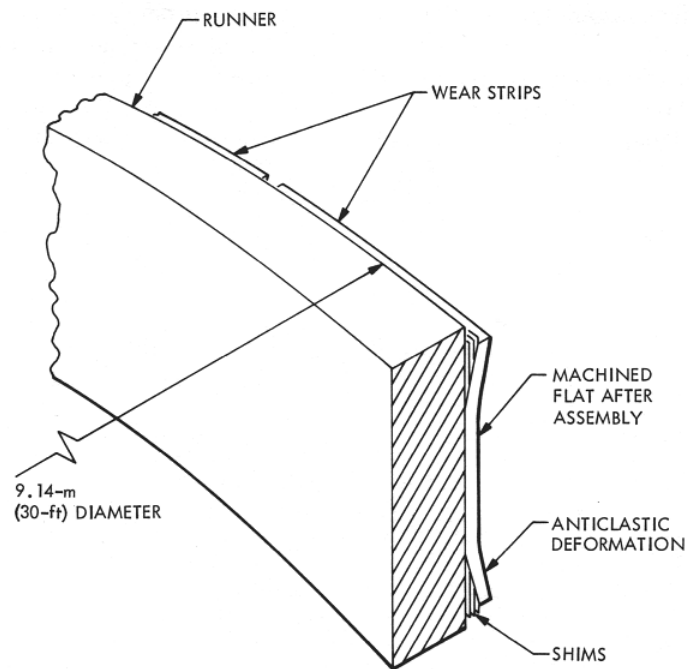
### IV. Summary of Test Results

The results of this test are summarized as follows:

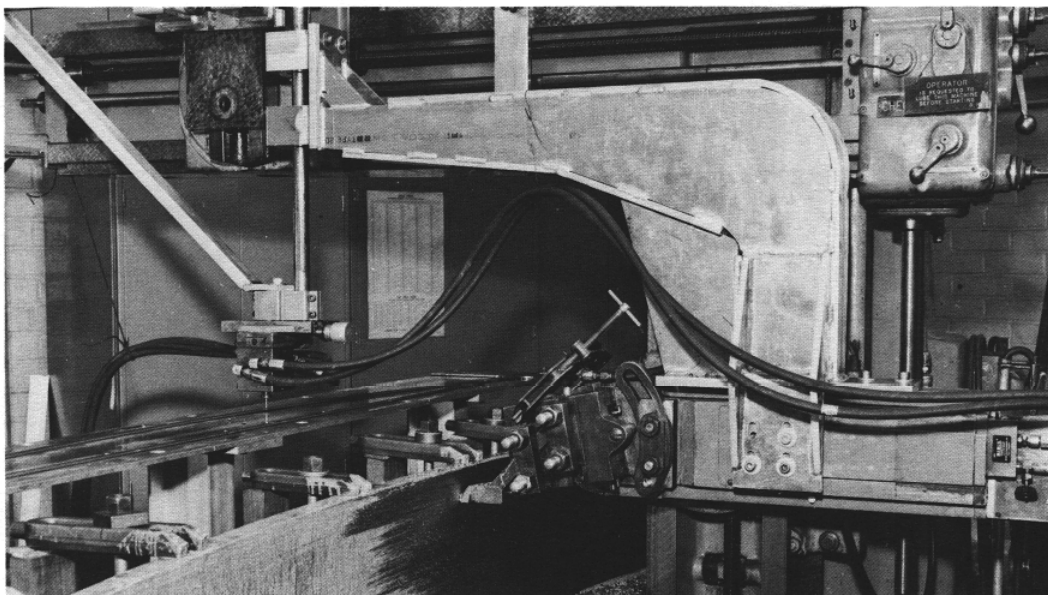
- (1) The longitudinal planer method appears to be desirable to keep the tool marks running in the direction of the mating bearing rollers.
- (2) A more desirable machine would be an actual "hydraulic tracer planer," which would be used in place of the attachment, or, better still, a numerically controlled planer. The latter would be the more desirable as all of the machine functions could be programmed beforehand, thus allowing higher speed.

- (3) A final thickness variation of 0.127 mm (0.005 in.) can be expected. This would cause an undesirable step across the adjoining segments and would require hand work in the final assembly.
- (4) It appears that the process of forming the plate cold, heat treating it, and then machining it on an appropriately equipped planer is a practical way of

achieving the desired final dimensional accuracy. Some hand working of the steps across adjacent segments may be required at final assembly, but the end product will be much more satisfactory than achieved so far. The proposed method should also be competitive with the previous method on a cost basis, and can be used for replacement parts as well as for new construction.



**Fig. 1. Runner and wear strip details**



**Fig. 2. Planer tracer control setup**